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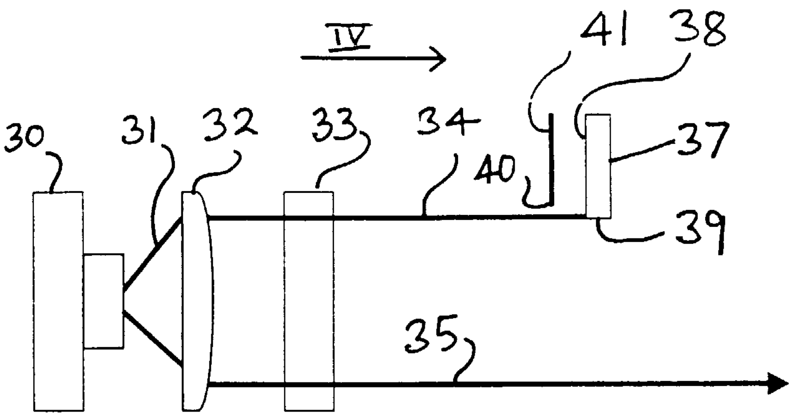

(57) Abstract: Laser apparatus comprises a laser assembly (30) for producing light having multiple lobes in its far field intensity pattern. A light feedback element (37) forms a resonant external cavity with the laser assembly (30) for returning to the laser assembly light (34) derived from a first lobe of the light produced by the laser assembly, an output beam (35) being derived from a second lobe. The light feedback element has a reflective surface (38) for reflecting back to the laser assembly light incident on the reflective surface. A spatial filter restricts the transverse modes of the feedback light to one or more selected transverse modes, and includes a masking element (41) positioned between the reflective surface and the laser assembly. The spatial filter is formed by a pair of opposed edges (39, 40) comprising an edge (39) of the reflective surface and an edge (40) of the masking element (41).

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LASER APPARATUS

The present invention relates to laser apparatus including a spatial filter for restricting the transverse modes of light propagation therein.

Amongst laser apparatus currently available, it is possible to provide substantially single mode operation in relatively inexpensive devices by limiting the lasing cross-sectional area to an area of approximately 1 x 3 microns. Typically such a device is formed by wafer techniques to give a semi-conductor device having a thickness in the region of 1 microns and cross-sectional width in the region of 3 microns. Such a single mode laser will typically provide an output power of 200 to 300 milli watts. If it is desired to provide a diode laser with a higher output, constructions known as broad area lasers, or diode laser arrays are provided, having approximately the same cross-sectional depth, but having a cross-sectional width of the order of 100 microns. Such devices can provide an output power in the region of 2 to 3 watts, but give multimode operation with a multilobe far-field intensity pattern. The result of this is that the output beam is no longer substantially diffraction limited, but instead the spatial beam quality is in the order of 10 to 1000 times the diffraction limit.

A number of techniques are known to reduce the transverse modes in the output beam of broad area lasers and laser diode arrays, and a commonly used technique is the provision of feedback into the laser by reflection from a feedback device forming an external cavity with the laser. Examples of such arrangements are disclosed for example in WO98/56087 (Torsana A/S).

The term feedback refers to the process where a fraction of the output energy returns to the active region of the laser structure, for example by means of reflection, diffraction, or scattering. The optical feedback then influences the field and carrier distribution in the laser causing it to change behaviour. For the case of laser diode arrays (and broad-area lasers) there may be provided two different external cavity configurations, referred to as an on-axis external cavity, and an off-axis external cavity. In the on-axis configuration all the far-field radiation is collected and directed towards the external reflector that returns a fraction of the incident energy. In the off-axis configuration, however, only a part of the two-lobe far-field (for example only the positive lobe) is directed towards the external reflector, which then that returns a fraction of the energy contained in that lobe.

It is known to provide spatial filtering in the feedback beam. For example in a paper entitled: "Characteristics of the off-centered apertured mirror external cavity laser array", C.J. Chang Hasnain, *et al*, Appl. Phys. Lett. Vol. 54. Pp. 484-486, 1989, there is disclosed an off-axis external cavity formed by positioning a feedback mirror in a collimated light beam derived from one lobe of the light output of a laser assembly. Light from the other lobe forms the output beam, which is aligned to pass by the feedback mirror. The feedback mirror has the configuration of a stripe having a width and position such as to favour a chosen order of transverse mode of the laser assembly, so as to provide spatial filtering. The spatial filtering is provided by the two longitudinal edges of the stripe mirror.

In the disclosure of WO98/56087 (Torsana A/S), a laser assembly such as a broad area laser or laser diode array produces an output light beam which in the free running state without feedback has multiple lobes in its far-field intensity pattern. A light feedback device such as a mirror, grating, or phase conjugate device, forms an external cavity with the laser assembly for returning to the laser assembly light derived from a selected first lobe of the far-field intensity pattern. An optical arrangement is provided to produce an output beam which is derived from a second lobe of the far-field intensity pattern. Most commonly the output of the laser assembly in the free running mode has two principal lobes positioned symmetrically on either side of a central axis of the laser assembly. In the prior art cited, a spatial filter is provided for restricting the transverse lasing modes of the feedback light to one or more selected transverse modes, preferably such that the laser is bought to lase in substantially a single transverse mode. The proportion of light returned to the laser assembly from the first lobe is such that the dominant lobe is the second lobe from which the output light beam is derived. In the disclosure of WO98/56087, the spatial filter is provided by a pair of razor blades mounted onto independent translators allowing adjustment of the spacing between the edges of the razor blades, and the position of the overall gap between the razor blades.

Further increases in power output can be obtained beyond broad area lasers and laser diode arrays, by devices of greater cross-sectional lasing area, commonly known as bar lasers or laser diode bars. Here a single monolithic structure is produced by conventional wafer technology, in which a series of spatially separated broad area lasers or laser diode arrays are positioned side by side along the laser bar, with the long dimension of each laser cross-section aligned lengthways along the bar. The result is a laser assembly which produces a much higher output power, of the order 10 to 100 watts, but the output beam has even poorer beam qualities due to the large cross-sectional area of the output facet. Furthermore the individual broad area lasers or laser diode arrays forming the bar, lase independently of each other with no predetermined phase relationship between them. Consequently such devices have limited use because although the power is high the brightness of the output is low. A laser diode bar has characteristics similar to the characteristics of a laser diode array or broad area laser, since a bar consists of separated laser diode devices. However, both the spatial coherence and the coherence length are decreased substantially for a bar as compared with the coherence properties of an array or broad area laser. The reason for this is that the output of a laser bar is in general an incoherent summation of the partly coherent output of the arrays of the bar.

In another disclosure, US-A-5,430,748 (MacCormack, *et al*), there is disclosed a similar laser apparatus in which off-axis feedback is provided by a phase conjugator reflecting back to the laser assembly light from one lobe of the far-field energy distribution pattern. Again an output beam is taken from light derived from the other lobe of the far-field distribution pattern. A spatial filter is provided in the feedback beam, formed by a pair of opposed edges comprising an edge of a prism and an edge of a masking element positioned between the prism and the laser assembly. Light passing through the spatial filter and reflected at right angles by the prism is passed to a further optical assembly including a lens system for focusing the light beam into the phase conjugating crystal. The feedback light beam is then retroreflected by the phase conjugate crystal to return through the prism and through the spatial filter, to the laser assembly. In the arrangement illustrated, the lens system is provided to focus the feedback lobe of the laser emission near the edge of the prism which forms part of the spatial filter. In a modification of the apparatus illustrated, it is recorded that in a comparison experiment the phase conjugate mirror was replaced with an ordinary high-reflectivity plane mirror, and the lens system of the apparatus was adjusted to form a focus at the mirror. Where the plane mirror is used, and the light in the feedback lobe is focussed directly at the surface of the feedback mirror, it was said in the prior disclosure that it was difficult to arrange alignment, and the arrangement was less successful than with the phase conjugate mirror. These difficulties arise from the difficulty of aligning the system when the feedback lobe is focussed at the surface of the plane mirror surface.

The systems for spatial filtering shown in WO98/56087 and US-A-5,430,788 both suffer from the disadvantage of complexity, and multiplicity of components. It is an object of the present invention to provide a spatial filter in a laser apparatus, having fewer components than in previous systems, providing a compact, axially arranged, assembly, and allowing easier alignment of the assembly.

According to the present invention there is provided laser apparatus comprising a laser assembly for producing light having multiple lobes in its far field intensity pattern; a light feedback element forming a resonant external cavity with the laser assembly for returning to the laser assembly a feedback light beam derived from a first lobe of the light produced by the laser assembly, an output light beam being derived from a second lobe; and a spatial filter for restricting the transverse modes of the feedback light to one or more selected transverse modes, the spatial filter including a masking element positioned between the feedback element and the laser assembly; in which the spatial filter is formed by a pair of opposed edges comprising an edge of the masking element and an edge of the feedback element.

Although the feedback device in arrangements according to the invention may take many different forms, it is particularly preferred that the light feedback element has a reflective surface for reflecting back to the laser assembly light incident on the reflective surface. For example, the light feedback element may be a mirror, preferably having a reflective surface which is a plane mirror surface. However in some arrangements the mirror may have a reflective surface which is a curved mirror surface. In another particularly preferred form of the invention, the light feedback element may be a reflective grating. Where a reflective grating is used, the grating may be aligned at an angle to the light incident on the surface thereof from the feedback lobe of the laser light. The masking element is preferably positioned substantially parallel to the light reflective surface of the grating, and is correspondingly also inclined to the incident light.

It is preferred that spatial filter is situated at the far field plane where the different spatial modes are most separated. It is particularly preferred that the apparatus includes an optical assembly for collimating light emitted from the laser assembly such that the light incident on the feedback element is a substantially collimated light beam having a far field energy distribution pattern. In the disclosure of US-A-5,430,748, an optical assembly is provided between the laser assembly and the masking element which is arranged to focus the feedback lobe of the laser light near the edge of the prism, i.e. to produce a focussed beam, not a collimated or near collimated beam. In the prior disclosure, in the modification using a plane mirror, difficulties were found in aligning the system. In the aspect of the present invention in which collimated, or approximately collimated light from the feedback lobe impinges on the reflective surface of the feedback element, it is easier to align the assembly correctly, and to achieve a highly filtered feedback return to the laser assembly. It is particularly preferred that the light beam impinging on the reflective surface of the light feedback element shall be highly collimated, although in some arrangements the light beam may be substantially collimated but focussed to some extent, for example having a focusing angle away from collimation in the range 1 to 10 degrees. Where the light is highly collimated, it is preferred that the reflective surface is a plane surface. Where the light impinging on the light feedback element is slightly convergent, the reflective surface may be made slightly curved, for example slightly concave, so as to focus the returned feedback light correctly.

It is a particularly preferred feature of the present invention that arrangements can be provided in which the feedback light beam and the output light beam are each aligned in substantially a single direction throughout the apparatus, and are both aligned in substantially the same direction throughout the apparatus. Preferably the said same direction is perpendicular to an output facet of the laser assembly.

It is another particularly preferred feature of the present invention that the masking element can be positioned directly adjacent the reflective surface of the feedback element without any optical component therebetween. It is also particularly advantageous that the masking element and the reflective surface of the feedback element can be positioned very close together, which produces accurate spatial filtering, particularly in combination with the preferred feature that the light striking the reflective surface is a collimated beam having a far-field energy distribution pattern, i.e. the spatial filter is located at the far-field plane determined by intermediate lens-optics. It is preferred that the masking element is spaced from the reflective surface of the feedback element by a distance less than 10mm. Preferably the said distance is less than 2mm, most preferably in the range 0.1 to 0.5mm, for example 0.2mm.

Conveniently in all aspects of the invention, the pair of opposed edges are parallel. Conveniently the masking element comprises a sheet of opaque material, for example formed from part of a razor blade.

In accordance with a particularly preferred construction embodying the invention, the masking element and the feedback element are mounted on a first carrier, and the apparatus includes a first translator for producing movement between the first carrier and a base on which the laser assembly is mounted. Conveniently the first translator is arranged to produce movement of the first carrier in a direction generally parallel to the reflective surface and transverse to the said edge of the reflective surface. In addition there may be provided a second translator for producing relative movement between the said pair of opposed edges. Conveniently the second translator is coupled between the masking element and the first carrier, for producing movement of the masking element relative to the first carrier. Conveniently the second translator is arranged to produce movement of the masking element in a direction generally parallel to the reflective surface and transverse to the said edge of the reflective surface.

Although less preferred, in other arrangements the masking element and the feedback element may be independently mounted on a structure which is fixed relative to the base supporting the laser assembly, and translators may be provided to move the two opposed edges independently of each other relative to the laser assembly.

Embodiments of the invention may incorporate a number of different forms of laser assembly, for example a broad area laser diode, or a diode array having a plurality of current electrodes along the longitudinal axis of the diode array.

It is particularly preferred that an output beam from the apparatus is taken directly from the laser assembly, after appropriate focusing and collimation, without the need to reflect the output beam from mirror surfaces before extraction. To achieve this, it is preferred that light derived from the said second lobe is directed to pass by the feedback element at a position which is spaced from the said edge of the reflective surface in a direction laterally away from the masking element.

Although the invention has application with multi lobe light produced by a laser assembly, in general, the invention has particular application where the light produced by the laser assembly has in its free running state without feedback two predominant lobes in its far-field intensity profile positioned symmetrically on either side of a principal longitudinal axis perpendicular to the output facet of the laser assembly, said feedback element being arranged to return to the laser assembly light derived from substantially only a first lobe and the output signal being derived from substantially only the second lobe.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic representation of an off-axis laser apparatus of known form such as disclosed in WO98/56087;

Figure 2 is a diagrammatic representation of an other known laser apparatus, of a kind shown in US-A-5,430,748;

Figure 3 is a diagrammatic representation of a first laser apparatus embodying the invention;

Figure 3a shows an alternative embodiment of the present invention, in which the light feedback element is provided by a reflective grating;

Figure 4 is a diagrammatic representation of an end view of the apparatus taken in the direction IV in Figure 3;

Figure 5 is a perspective view of various components of the laser apparatus shown in Figure 3;

Figure 6 is a perspective view of a spatial filter and light feedback element forming part of the apparatus shown in Figure 5;

Figure 7 is a side view of the assembly shown in Figure 6, the view being taken along the direction VII in Figure 6; and

Figure 8 is a side view of the assembly shown in Figure 6, the view being taken in the direction VIII, in Figure 6.

Figure 1 shows a known arrangement, as described for example in WO98/15994, in which a semi-conductor diode laser 11 generates light with a dual lobe far-field intensity pattern passing through lenses 12 and 13 to produce a collimated light beam comprising a feedback beam 14 derived from one lobe and an output beam 15 derived from the other lobe. The feedback beam 14 passes through a spatial filter 16 to be incident upon a reflective surface 17 of a light feedback element 18 which may for example be a plane mirror. The feedback light 14 is reflected orthogonally back through the lens system 12, 13 to be injected back into the diode laser 11. The lens 12 is a fast axis collimation lens and the lens 13 is a slow axis collimation lens. The feedback beam 14 may also passes through a spectral filter (not shown). The output beam 15 is reflected by a first output mirror 20 and a second output mirror 21 to form a final output beam 15 emerging in the same direction as the original light from the diode laser 11. Conveniently the diode laser 11 is a GaAlAs laser diode array or broad area laser. The feedback beam 14 is passed through the spatial filter 16 and frequency selective element (if present) to isolate a substantially single transverse mode and single longitudinal mode respectively, for the feedback light.

In the free running mode, without feedback, the output of the laser diode array 11 is a multi mode light beam consisting of a superimposition of transverse array modes. Each array mode has a double lobe intensity profile in the far-field.

The array modes are distinguished by different frequencies and different radiation angles. The off-axis feedback illustrated in Figure 1 selects and re-injects one of the lobes of a single array mode, forcing the laser diode array 11 to lase in this mode only. The resulting single mode radiation is strongly asymmetric with a dominant lobe which forms the output beam 14, and a small lobe which forms the feedback beam 15.

The purpose of the spatial filter 16 and mirror 18 is to form an adjustable stripe mirror. The adjustments required are that the slit can be adjusted, the position of the slit can be adjusted, and the mirror can be tilted. The stripe is produced by using the adjustable aperture formed conveniently by two razor blades mounted on two independent translators. Behind the spatial filter 16 the mirror 18 is mounted to be tiltable about two axes. Because of the complexity of these constructions, the output mirror 20 needs to be inserted into the output beam 15 in front of the spatial filter 16 in order to couple out the final output beam. The mirror 20 also needs to be mounted on a translator in order to position the mirror 20 transverse to the beams 14 and 15, in a correct position so that the output beam 15 is reflected out by the mirror 20, but the feedback 14 passes past the mirror 20 to the feedback mirror 18. The first output mirror 20 needs to be adjusted carefully so as to be positioned in the path of the output beam 15 but not to encroach on the feedback beam 14. The second output mirror 21 is provided because a normal commercial requirement is to have the beam coupled out at the opposite end of the equipment from where the diode laser 11 is mounted. To align the output axially, the mirror 21 also needs to be adjustable in angle.

In Figure 2, there is shown another known arrangement, as disclosed in US-A-5,430,748. Only those components relevant to the present invention will be described in detail. Components corresponding to those of Figure 1 are indicated by the same reference numerals. The apparatus of Figure 2 includes a laser diode array producing an output lobe beam 15 and a feedback lobe beam 14, a spatial filter 16, and a feedback mirror 18, which in a first arrangement is a phase conjugate mirror. The array 11 of broad area lasers produces light which passes through a collimating lens 22, a half-wave plate 23, and a focusing lens 24 for focusing one lobe of the laser beam near the edge of a prism 25 which reflects the light as a feedback beam through further lens 26, mirrors 27 and 28, and lens 29 to the phase conjugate mirror 18. The phase conjugate mirror 18 retroreflects the feedback beam through the components described, to inject feedback light into the laser diode array 11. The second lobe of the light output from the laser array 11 forms the output beam 15.

The spatial filter 16 masks part of the input face of the prism 25, so that the edge of the spatial filter 16 limits part of the feedback beam entering the prism. The edge of the prism 25 also provides spatial filtering as part of the feedback beam misses the prism and is not reflected by the prism onwards towards the phase conjugate mirror 18. In a modification, which is described as a comparison, the phase conjugate mirror 18 is replaced with an ordinary high-reflectivity plane mirror, and the lens pair 26, 27 is adjusted to form a focus at the plane mirror. The modified arrangement is said to be less successful than the arrangement with the phase conjugate mirror. It is believed that the difficulty in alignment which is experienced with the modified arrangement of the known apparatus, arises because the feedback light beam is focussed as a point source on the surface of the mirror, which diffracts light back into the diode laser assembly even if the plane mirror is not precisely aligned orthogonally to the incident radiation. Consequently there is no easy indication of when the feedback beam is correctly aligned.

In Figure 3 there is shown a diagrammatic representation of a first embodiment of the present invention. A diode laser array 30 generates light 31 having dual lobes in its far-field distribution pattern. The light 31is transformed by a fast axis cylindrical lens 32 and an orthogonal slow axis collimation lens 33 to produce an output beam 35 derived from one lobe of the laser light, and a feedback beam 34 derived from the other lobe of the laser light. The feedback beam 34 may pass through a spectral filter (not shown) and is directed to a feedback element 37, which in the embodiment shown is constituted by a plane mirror having a plane reflective surface 38. A spatial filter is provided by a pair of opposed edges consisting of an edge 39 of the reflective surface 38, and an edge 40 of a masking element 41, conveniently provided by a part of a razor blade. The mirror 37 is adjustably movable relative to the laser array 30 in a direction perpendicular to the edge 39, and the masking element 41 is adjustable in the same way. By adjusting one or other or both of the mirror 37 and the masking element 41, it is possible to adjust the width of the stripe mirror, and the position thereof. As can be seen, the simplification of the adjustment mechanism for the stripe mirror, allows the output beam 35 to pass by the edge 39 of the mirror, and to be coupled out of the apparatus without the need for reflection as shown in Figure 1. Figure 4 shows a diagrammatic view in the direction of the arrow IV in Figure 3, and shows how part of the mirror 37 is obscured by the masking element 41.

Advantages of this embodiment are that it is a simple design with fewer components than known systems. The output beam 35 is coupled out generally along the axis of the feedback beam 34 which gives good angular alignment because the feedback arm of the apparatus provides a reference during general alignment. The design can be made considerably more compact since all components are mounted along the same axis, defined by the feedback arm of the apparatus. This avoids the Z-shaped path of the output beam shown in Figure 1 in known arrangements.

In comparison with the known arrangement shown in Figure 2, there is particular advantage because the feedback beam 34 which strikes the plane mirror 37 is a collimated light beam, having a far-field energy distribution pattern. Because the beam is collimated it can easily be aligned to strike the reflective surface 38 orthogonally. If the mirror 37 is not orthogonal to the feedback beam 34, the reflected beam will clearly be mis-aligned, and feedback will not be achieved. Because the beam 34 is collimated, it is easier to determine whether correct or optimal alignment is present or not, in comparison with the plane mirror arrangement of Figure 2 where the feedback light is produced in effect by a point source on the surface of the plane mirror.

It is a particular feature of the embodiment described that the masking element 41, which conveniently is a sheet of opaque material, can be positioned directly adjacent the reflective surface 38 of the mirror 37 without any optical component therebetween. Preferably the spacing between the masking element 41 and the mirror 37 is in the range 0.1 to 0.5mm, conveniently at 0.2mm.

In Figure 3a there is shown a modification of the embodiment of Figure 3, in which the plane mirror 37 is replaced by reflective grating 42 having a reflecting surface 43. In this arrangement the masking element 41 is positioned parallel to the reflecting surface 43 of the grating 42, and is also therefore inclined to the general longitudinal axis of the apparatus. Again provision is made for moving adjustably the components 41 and 42, in the same manner as in the embodiment of Figure 3.

Reference will now be made to Figures 5 to 8, which illustrate in more detail one construction of the embodiment of Figure 3. In Figures 5 to 8, components corresponding to those in Figure 3 will be indicated by like reference numerals.

In Figure 5 the diode laser array 30 is omitted for simplicity, but in use is mounted on a cylindrical diode mount indicated at 51. At the other end of the apparatus shown, an end plate 52 is provided, which is rigidly connected to the diode mount 51 by three parallel spaced apart rods 53. Other components are adjustably mounted on the rods 53 allowing axial movement of the components along the apparatus. The first collimating lens 32 is mounted on a first lens mount 54 which is axially adjustably movable along the rods 53. The second collimating lens 33 is correspondingly mounted on a second lens mount 55. The lenses 32 and 33 are an orthogonally arranged pair of cylindrical lenses, which effect collimation of the laser beam in two orthogonal directions.

Behind the second lens mount 55 is provided a feedback mount 56 which again is adjustably movably mounted on the rods 53. The feedback mount 56 is shown in more detail in Figures 6, 7 and 8 to which reference will now be made in particular. As shown in Figures 7 and 8, the feedback mount 56 is formed of a single, machined, block of aluminium having three main sections indicated as first, second and third sections 57, 58 and 59. Each section is in the form of a generally cylindrical ring having a central aperture through which the light beams pass, and having cut-outs to accommodate the rods 53. The second section 58 is joined to the first section 57 by two spaced apart, diametrically opposed, waist regions 60 and 61. The third section 59 is similarly connected to the second section 58 by waist regions 62 and 63.

Angular adjustment of the sections 57, 58 and 59 can be made by altering the tilt of the sections 57, 58 and 59 relative to each other, in each case in two orthogonal directions, by very slight bending of the waist regions 60 to 63. The bending is achieved by screw-threaded adjusting bolts passing through apertures in the sections 57, 58 and 59 and bearing respectively on various of these sections. The screw-threaded bolts are omitted for simplicity from the diagrams. By rotating the bolts pressure can be applied to the sections so as to produce the required bending of the waist portions, and to produce tilting of the sections in two orthogonal directions.

Considering now the mounting of the mirror 37 and masking element 41, these are both mounted on a first carrier 64 which is located on the third section 59. Referring to Figure 8, on one side the first carrier 64 has a plane face 65 parallel to the longitudinal axis of the apparatus and perpendicular to the edges of the mirror and masking element co-operating with a side wall 68 of the third section 59, and on the opposite side has two triangular faces 66 and 67 co-operating with corresponding surfaces on a side wall 69 of the third section 59. On the opposite side of the third section 59 the side wall 68 has a corresponding plane face co-operating with the plane face 65. The mounting of the first carrier

64 in this way allows transverse translational movement of the carrier 64 relative to the third section 59 in a direction lying generally in the plane of the mirror 37, and perpendicular to the edge of the mirror 37.

Mounted on top of the first carrier 64 is a second carrier 70 on which is fixedly mounted the masking element 41. The second carrier 80 has side edges 71 and 72 which are slidably mating with corresponding internal side edges 73, 74 of the first carrier 64. This arrangement allows sliding of the second carrier 00 relative to the first carrier 64, in a direction lying generally parallel to the surface of the mirror 37, and perpendicular to the edge of the mirror 37. In Figure 6 there are shown slots 77 and 78 in the second carrier 70, and internally screw-threaded apertures 79 and 80 in the upper surface of the first carrier 64. When the second carrier 70 has been moved to the correct position relative to the first carrier 64, it is secured in place by screw-threaded bolts (not shown) passing through the slots 77 and 78 into the screw-threaded apertures 79 and 80, to secure it in place.

All of the movements described, of the ring sections 57, 58 and 59, and of the first and second carriers 64 and 70, are effected in practice by screw-threaded translators acting between the various components by rotation of the screw-threaded translators, to effect controlled translational movement, will be apparent to one skilled in the art. When correct adjustment has been made, further screw-threaded components (not shown) form locking components which lock the adjusted components in place.

CLAIMS

1. Laser apparatus comprising:

a laser assembly for producing light having multiple lobes in its far field intensity pattern;

a light feedback element forming a resonant external cavity with the laser assembly for returning to the laser assembly a feedback light beam derived from a first lobe of the light produced by the laser assembly, an output light beam being derived from a second lobe; and

a spatial filter for restricting the transverse modes of the feedback light to one or more selected transverse modes, the spatial filter including a masking element positioned between the feedback element and the laser assembly;

in which the spatial filter is formed by a pair of opposed edges comprising an edge of the masking element and an edge of the feedback element.

2. Apparatus according to Claim 1, in which the feedback light beam and the output light beam are each aligned in substantially a single direction throughout the apparatus, and are both aligned in substantially the same direction throughout the apparatus.

3. Apparatus according to Claim 2, in which the said same direction is perpendicular to an output facet of the laser assembly.

4. Apparatus according to Claim 1, in which the masking element is positioned directly adjacent the feedback element without any optical component therebetween.

5. Apparatus according to Claim 4, in which the masking element is spaced from the feedback element by a distance less than 10mm.

6. Apparatus according to Claim 5, in which the said distance is less than 2mm.

7. Apparatus according to Claim 6, in which the said distance is in the range 0.1 to 0.5mm.

8. Apparatus according to Claim 1, in which the light feedback element has a reflective surface for reflecting back to the laser assembly light incident on the reflective surface.

9. Apparatus according to Claim 8, in which the light feedback element is a mirror.

10. Apparatus according to Claim 9, in which the reflective surface is a plane mirror surface.

11. Apparatus according to Claim 9, in which the reflective surface is a curved mirror surface.

12. Apparatus according to Claim 8, in which the light feedback element is a reflective grating.

13. Apparatus according to Claim 1, including an optical assembly for collimating light emitted from the laser assembly such that the light incident on the feedback element is a substantially collimated light beam having a far field energy distribution pattern.

14. Apparatus according to Claim 1, in which the pair of opposed edges are parallel.

15. Apparatus according to Claim 1, in which the apparatus includes a translation assembly for varying the lateral positions of the said two edges relative to each and relative to the laser assembly.

16. Apparatus according to Claim 1, in which the masking element and the feedback element are mounted on a first carrier, and the apparatus includes a first translator for producing movement between the first carrier and a base on which the laser assembly is mounted.

17. Apparatus according to Claim 16, in which the first translator is arranged to produce movement of the first carrier in a direction generally parallel to the reflective surface and transverse to the said edge of the reflective surface.

18. Apparatus according to Claim 16, including a second translator for producing relative movement between the said pair of opposed edges.

19. Apparatus according to Claim 18, in which the second translator is coupled between the masking element and the first carrier, for producing movement of the masking element relative to the first carrier.

20. Apparatus according to Claim 18, in which the second translator is arranged to produce movement of the masking element in a direction generally parallel to the reflective surface and transverse to the said edge of the reflective surface.

21. Apparatus according to Claim 1, in which the masking element comprises a sheet of opaque material.

22. Apparatus according to Claim 21, in which the masking element is formed from a razor blade.

23. Apparatus according to Claim 1, in which the laser assembly comprises a broad area laser diode.

24. Apparatus according to any of Claim 1, in which the laser assembly comprises a diode array having a plurality of current electrodes spaced apart along the longitudinal axis of the diode array.

25. Apparatus according to Claim 1, in which light derived from the said second lobe is directed to pass by the feedback element at a position which is spaced from the said edge of the feedback element in a direction laterally away from the masking element.

26. Apparatus according to Claim 1, in which the light produced by the laser assembly has in its free running state without feedback two predominant lobes in its far field intensity profile positioned symmetrically on either side of a principal longitudinal axis perpendicular to the output facet of the laser assembly, said feedback element being arranged to return to the laser assembly light derived from substantially only a first lobe and the output light being derived from substantially only the second lobe.

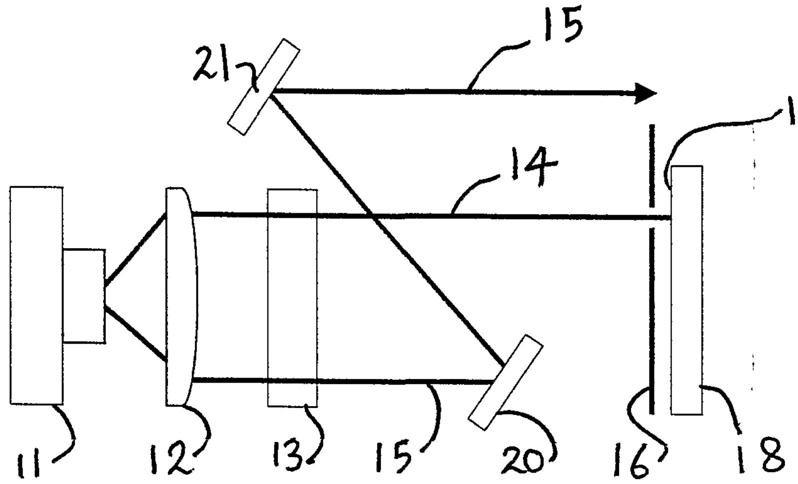

FIG 1

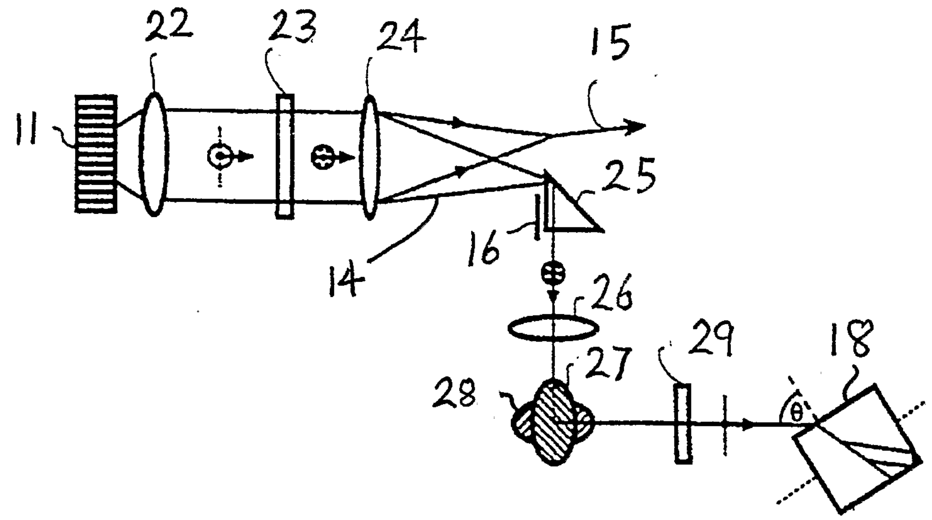

FIG 2

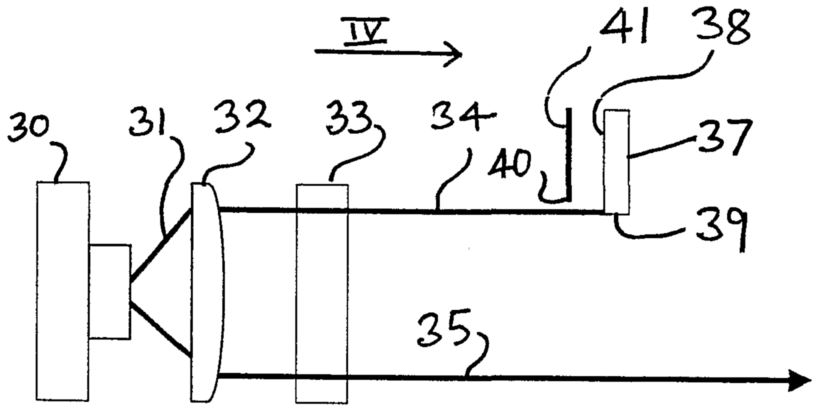

FiG 3

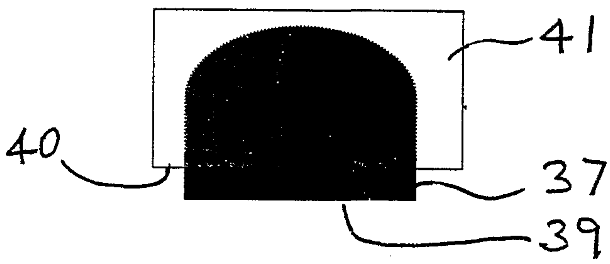

FIG 4

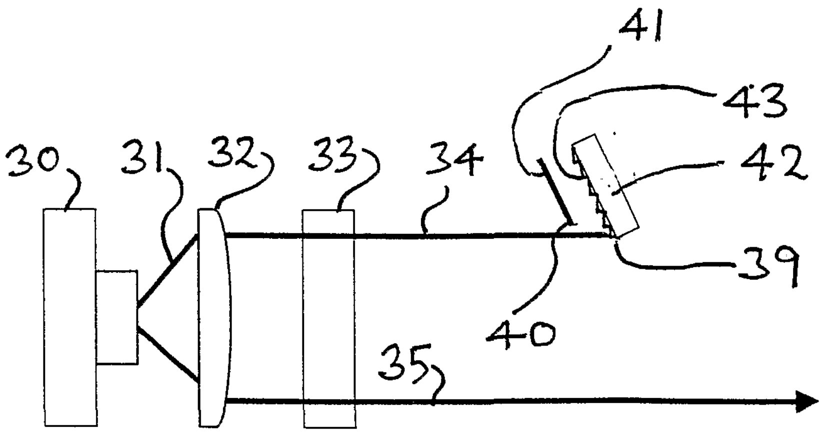

FiG 3a.

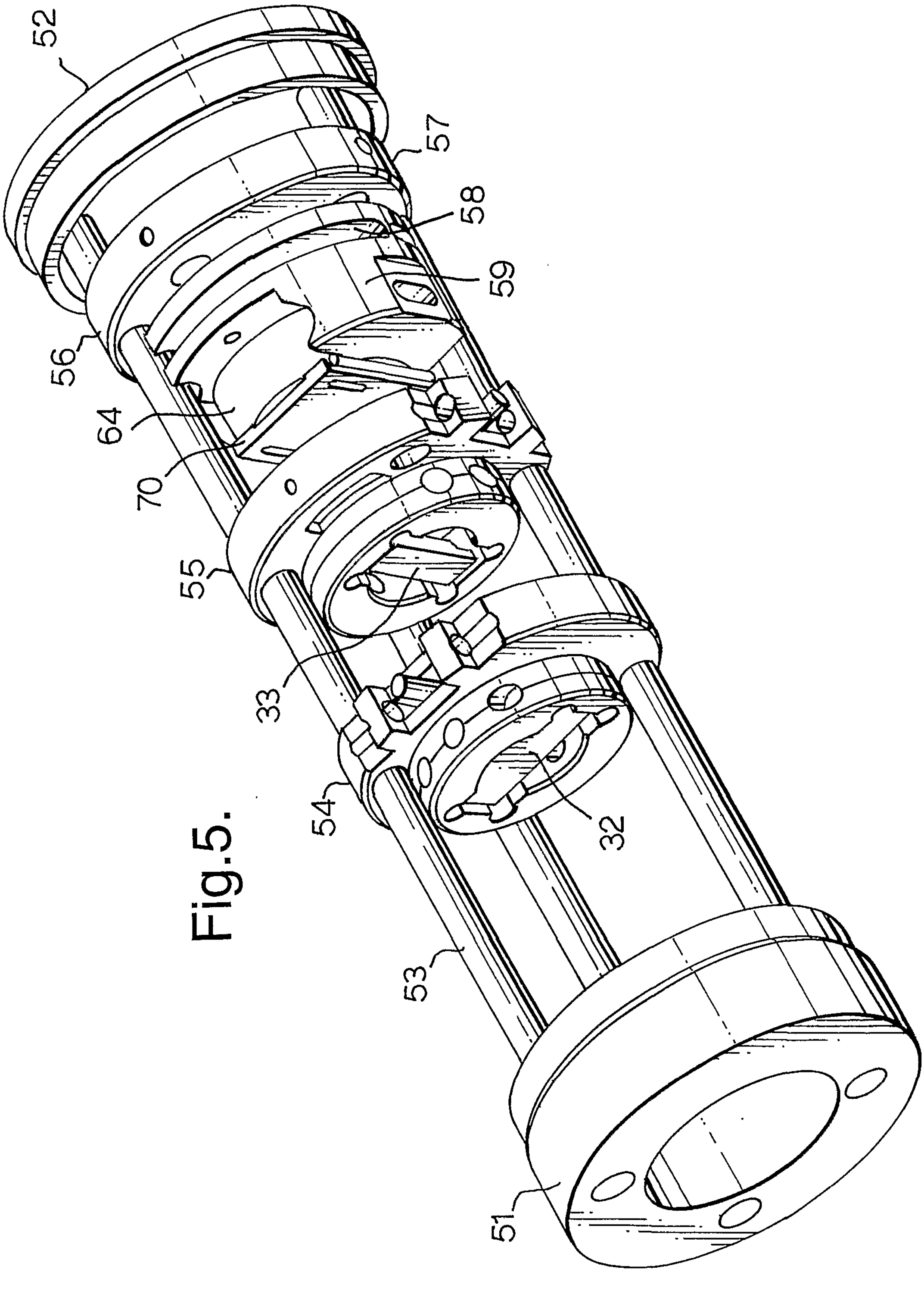

Fig.5.

Fig.6.

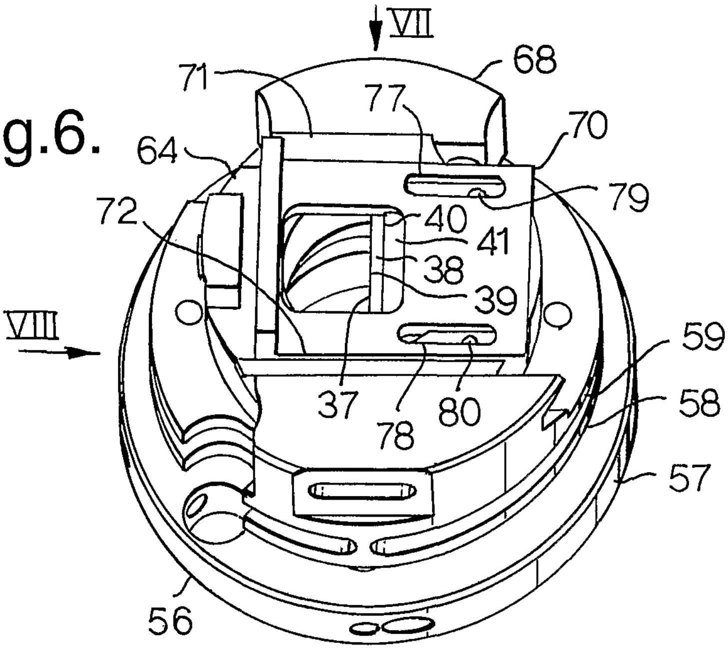

Fig.7.

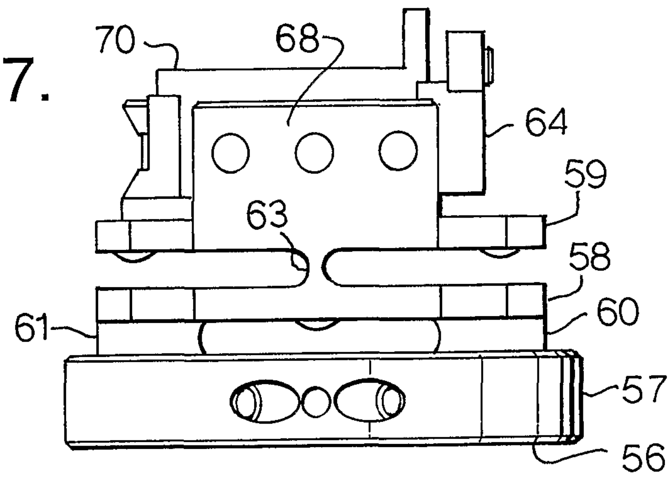

Fig.8.